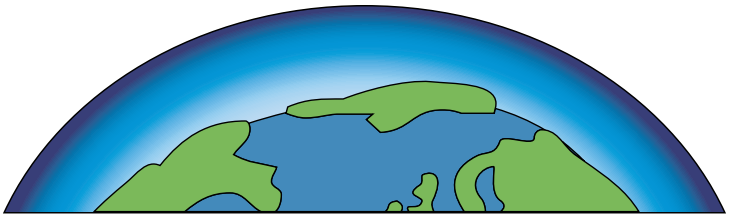


Lesson 1: Atmospheric Science Training Module

Students review the basic requirements for human survival. Using an online, multimedia module, they change amounts of gases in our atmosphere and draw conclusions about the amount of each gas that is necessary for human survival.

Main Concept: Certain atmospheric conditions help to support human survival.

Scientific Question: What atmospheric conditions are required for human survival?

Objectives	Standards
• Students make changes to our atmosphere and write descriptive, objective observations of the effects of these changes on Earth. • Students will identify the characteristics of our atmosphere that are required for human survival.	**Meets:** NSES: A (5-8) #1 ISTE: 3, 5 **Partially meets:** NSES: D (5-8) #1.8 **Addresses:** 2061: 4B (6-8) #2

Assessment	Abstract of Lesson
Write-up in Astro Journal.	Students review the basic requirements for human survival and predict how human survival requirements are met by characteristics of our atmosphere. They engage in an online Atmospheric Science Training module in which they make changes to the Earth's atmospheric conditions and observe the effects of these changes on Earth. They then draw conclusions about which atmospheric conditions are necessary to support human survival.

Prerequisite Concepts	Major Concepts
• Humans need water, oxygen, food, gravity, a moderate temperature, and protection from poisonous gases and high levels of radiation to survive. (Astronomy Lesson 1) • Gases have no definite shape or volume due to their extremely weak molecular bonds, which allow them to move freely. (Astronomy lessons 3 and 4) • Systems consist of many parts that usually influence each other. Something may not work as well (or at all) if a part of the system is missing, broken, worn out, mismatched or misconnected. (Astronomy Lesson 7) • Scientific observations are detailed descriptions of what can be learned using the senses and scientific instruments. These scientific observations do not include ideas, opinions, or speculations about what is being observed. • A cause is something that produces an effect or result.	• The following atmospheric characteristics allow Earth to remain habitable to humans: • 0. 0001 to 20% water vapor • 0.001 to 0.03% carbon dioxide • more than 80 Dobson Units of Ozone in the stratosphere • 15 to 30% oxygen • More than 5% nitrogen

Note to Teacher: Atoms, elements, molecules, chemical reactions, oxidation, and air pressure are all explored and defined in later lessons. In this lesson, students simply need to make good observations about "what" is needed for human survival. Lessons 2-7 will give them the "whys" behind these needs.

Suggested Timeline (45-minute periods):

Day 1: Engage and Explore Part 1 Sections
Day 2: Explore Part 2 Section
Day 3: Explain, Extend/Apply and Evaluate Sections

Materials and Equipment:

- Human Survival Transparency
- 1 Atmospheric Chemist Career Fact Sheets for each group
- 1 Atmospheric Conditions Transparency
- A class set of Astro Journal Lesson 1: Atmospheric Science Training Module
- 1 Planetary Atmosphere Comparison Chart for each group
- 1 copy Atmospheric Science Training Walkthrough (optional)
- 1 to 30 computers with Internet browser, Internet connection and the Flash 6 Player installed*
- A printer connected to the computers
- Chart paper
- Overhead projector
- LCD projector or TV connected to a computer with video card (optional)

Preparation:

- Prepare class sets of Astro Journal.
- Prepare overhead transparencies.
- Make copies of Astro Journal, Planetary Atmosphere Comparison Chart and Atmospheric Chemist Career Fact sheets.
- Download and install Flash 6 Players on computers from http://www.macromedia.com/downloads. Test these at http://astroventure.arc.nasa.gov by clicking "Atmospheric Science Training."
- Prepare chart paper with major concept of the lesson and human survival needs to post at the end of the lesson.

*** System Requirements to Run Atmospheric Science Training Module**

Operating System	Browser
Windows 95 Windows 98 Windows Me	Internet Explorer 4.0 or later (Internet Explorer 5.0 or later is recommended), Netscape Navigator 4 or later, Netscape 7.0 or later (Netscape 6 is not recommended)
Windows NT Windows 2000 Windows XP or later	Internet Explorer 4.0 or later, Netscape Navigator 4 or later, Netscape 7.0 or later, with standard install defaults (Netscape 6 is not recommended)
Macintosh: System 8.6 System 9.0 System 9.1 System 9.2	Netscape 4.5 or later (Netscape Communicator 4.7 or Netscape 7.0 are recommended), Netscape 7.0 or later, (Netscape 6 is not recommended) Microsoft Internet Explorer 5.0 or later
Macintosh OS X 10.1 or later	Netscape 7.0 or later (Netscape 6 is not recommended), Microsoft Internet Explorer 5.1 or later

RAM
The minimum requirement for RAM is 32 MB; however, the animations will run slowly and it will be slow sending the Astro Journal and Certificate to the printer at the end of the module. We recommend a minimum of 64 MB.

Sound
Astro-Venture uses narration and some sound effects. Computers will require a sound card and either headphones or speakers. Pairs of students using the same computer can use a y-cable to connect two pairs of headphones to one computer.

Differentiation:

Accommodations
For students who may have special needs:
- Pair advanced students with students that may need more guidance. Have them type the observations that the student verbalizes.
- Have students draw their predictions and other Astro Journal responses.

Advanced Extensions
Research and report on whether other gases such as helium, methane, argon, neon, krypton, and hydrogen are necessary for life and why or why not.

Engage (approximately 10 minutes)

1. **Review human survival needs (Astronomy Lesson 1), astronomical conditions that support human survival (Astronomy Lesson 2), systems (Astronomy Lesson 7), and introduce the purpose of this lesson/unit.**
   - Question: As members of the Astro-Venture Academy, what is our goal?
   - *Answer: Our goal is to find, study, and design planets that would be habitable to humans.*

   - Question: In the first lesson of Astronomy, what elements did you learn are necessary for human survival?
   - *Answer: The elements humans need for survival are: food, gravity, oxygen, water, a moderate temperature, and protection from poisonous gases and high levels of radiation.*

2. **Put up the Human Survival Transparency outlining these needs, reasons, and factors that provide for these needs.**
   - Question: In Astronomy, which of these necessary elements did we learn are influenced by astronomical conditions in our star system and planet?
   - *Answer: We learned that star type, orbital distance, and planetary mass all work together to determine the surface temperature of our planet, which determine whether the planet can have liquid water. We also learned that planetary mass determines the amount of gravity on a planet and that the orbit of any large objects such as Jupiter could disrupt this system.*

- Write these factors on the transparency for Moderate Temperature under "What Factors Provide This" as follows:

Humans need:	Reason:	What Factors Provide This:
Food	Gives us energy so that we can move, grow and function. It also gives us nutrients to build and mend bones, teeth, nails, skin, hair, flesh and organs.	
Oxygen	Helps us to obtain energy from sugars.	
Water	Allows nutrients to circulate through the body, allows the body to filter out waste and poisons and helps to regulate body temperature.	(related to temperature)
Moderate temperature (Average global temperature below 50° C)	Allows us to maintain an average body temperature of 98.6° F/37°C and to maintain water in a liquid state at all times.	Star type Orbital distance Planetary mass (Orbits of large planets/ objects could disrupt)
Protection from poisonous gases and high levels of radiation	To prevent cancer, disease and damage to the body.	
Gravity	Allows our biological systems to develop and function normally.	Planetary mass

- Question: So far, we've mostly only looked at the needs for a moderate temperature, gravity, and water, which are pretty important. If a planet has all of these astronomical conditions, is it habitable to humans? Explain.
- *Answer: It is not necessarily habitable to humans, because it may not have other conditions necessary for human habitation. The Earth is a system and requires many different factors to work together for the system to work.*

- Question: What could happen if a part of the system were missing or broken?
- *Answer: The system may not work as well (or at all).*

- Question: What other needed elements still need to be understood in order to make sure a planet is habitable to humans?
- *Answer: We need to understand what factors will allow our planet to have food, oxygen, and protection from poisonous gases and high levels of radiation.*

- Say: We will now begin to explore Earth's atmosphere and how it supports our survival needs, so that we can determine what conditions to look for on other planets and what to include in the design of a habitable planet.

3. Draw on students' prior knowledge of the atmosphere and gases (Astronomy Lessons 3 and 4).

- Question: What is the atmosphere?
- *Answers may include: The atmosphere is air that surrounds the planet.*

- Question: Can you see the atmosphere? How do you know it is there?
- *Answer: Air is mostly transparent, but sometimes you can see clouds or fog in the atmosphere. We know it is there, because we can feel it and can see the wind blowing trees and other things around.*

- *Question: How high up does the atmosphere go? How do you know?*
- *Answers may include: It goes up very high (hundreds of kilometers), because we can see clouds up there, and because airplanes (which need air to fly) can fly very high.*

- Question: What is the atmosphere made of?
- *Answer: (Some students may know the specific gases. At this point we are mostly making sure that students understand that the atmosphere is composed of gases.)*

- Question: In Astronomy, what did we learn about the characteristics of gases, and what determines these characteristics?
- *Answer: We learned that gases have no definite shape or volume due to their extremely weak molecular bonds, which allow them to move freely.*

4. Present the Scientific Question for this lesson.

- Scientific Question: What atmospheric conditions are required for human survival?
- Tell students that they will be role-playing scientists and using a computer activity to find out which atmospheric conditions humans need to survive and why.

Explore — Part 1 - (approximately 35 minutes)

1. Introduce Atmospheric Science careers.

- Tell students that, as they go through the Atmosphere module, they will be role-playing atmospheric chemists.
- Ask students what kinds of things they think an atmospheric chemist might do and what kind of knowledge they might need to have.
- Pass out the Atmospheric Chemist Career Fact Sheets for students to read and discuss this career.

2. Put up the Atmospheric Conditions Transparency, and help students identify possible atmospheric conditions for human survival.

- Say: In the Atmosphere section of Astro-Venture, we will be focusing on the gases that can make up a planet's atmosphere, and we will examine how these gases help to support the conditions we need to survive. We will call these conditions the "atmospheric conditions."

- Question: What do you think are some of the characteristics of our atmosphere that allow Earth to be habitable to humans?
- *Answer: (Accept all answers. Record these ideas on the Atmospheric Conditions Transparency under Predicted Atmospheric Condition.)*

3. Have students record their predictions in the Prediction section of their Astro Journal of the astronomical conditions that they predict are necessary for human habitation on a planet.

4. Introduce students to the Astro-Venture Atmospheric Science Training Module

- Tell students that they will be engaging in an online activity where they will change aspects of the atmospheric conditions of our planet and will observe the effects on Earth. They will then draw conclusions about the atmospheric conditions needed for human survival.

- Tell students that as they go through this module, they will be Astro-Venture Junior Atmospheric Chemists, and will be evaluated on how detailed their observations are, and whether they give reasons for the effects they observe. They will be able to use their notes on the Astro Challenge, so they should take thorough notes.

- You may want to model for students an example of a "good observation." Either project from a computer for the class to see or create transparencies of screen shots included in this lesson to walk the students through the following. (On the computer, you will need to click through the introduction to get to this part.)
  - Click "Water Vapor."
  - Click "none."
  - Click "Play" to see the effect on Earth.

  - Ask students to describe what happened to Earth and why. You can click the "Replay" button to see the animation as many times as is you want. Also, you may want to click Astro Facts to read background information that may help to understand what is happening in the animations and to model for students the use of the Astro Facts.

  - Record a good example of the kinds of observations you expect from students such as: "First the animals died. Then the plants died. It became cold."

    Note to Teacher: The sequence of events in this module is important. You may want to model this for students.

  - Click "Enter" to see another scientist's observation. Stress to students that they do not need to type the exact same thing, but should have the same general idea.

    Note to Teacher: Students can change their answer after they click "Enter." Both their original answers and their new answers will be printed in their Astro Journal so that you can see if they are making good, initial observations.

  - Point out to students that when they have completed an observation, the factor that they chose turns purple. They must complete all observations in all five major sections before they can advance to the Astro Challenge section.

    Note to Teacher: Some students may wonder why they can't just find the characteristics that allowed Earth to remain habitable and go on. Making good observations about the effects of life-threatening levels will help students understand why each gas amount is important to life.

  - Click "Astro Facts" to read helpful background information about each main topic. This information can help students understand some of the effects they are observing and the overall importance of each gas to human life.
  - Within the "Astro Facts," glossary words are in white. Click a white word and the definition will come up in a box. Click the "X" to close this box.
  - Click the back arrows to return to the animations.
  - Click "medium."
  - Click "Play."
  - Ask students to give a detailed observation such as, "The Earth would remain habitable."

Explore — Part 2 - (approximately 45 minutes)

1. **Have students engage in the Atmospheric Science Training module individually, in pairs, small groups, or as a class.**
   - Students should visit: http://astroventure.arc.nasa.gov and click "Atmospheric Science Training."

Note to Teacher: You will need the Flash 6 Player plug-in, which can be downloaded and installed from http://www.macromedia.com/downloads. When tested with grades 5-8, the average completion time was 30 minutes with a range of completion times between 22 to 32 minutes. Please note that this was the completion time when students used the Astro Facts very little or not at all. It's possible that with your encouragement to use the Astro Facts that students will make better use of this resource and will take longer to complete the module. Also, you will want to have accessibility to a printer, so students can print their Astro Journals at the end of the module. These can be used for evaluation purposes. Students will also receive a certificate of achievement for completing the module. Make sure students are clear about the printing rules for both the Astro Journal and the certificate. After the Astro Challenge, they will have the option to print these items. This will be the only opportunity to print; students cannot go back later to print. If you want to take the whole class through the module using one computer, use the Walkthrough at the end of this lesson as a guide.

Explain — (approximately 15 minutes)

1. **Have students fill out the Results and Conclusion section of their Astro Journals.**

2. **Discuss students' Conclusions and record them on the Atmospheric Conditions Transparency.**
   - Question: What atmospheric conditions did you observe are necessary for human habitation of a planet?
   - *Answer: (Record on the board) We need:*
     - *0.0001 to 20% water vapor*
     - *0.001 to 0.03% carbon dioxide*
     - *more than 80 Dobson Units of ozone in the stratosphere*
     - *15 to 30% oxygen*
     - *More than 5% nitrogen*
   - Question: Why do we need each of these? What happens to the planet otherwise?
   - *Answer: (Record the reasons next to each factor)*

Observed Atmospheric Condition	Reason
0. 0001 to 20% water vapor (medium levels)	To maintain a moderate temperature on Earth. To provide water for life.
0.001 to 0.03% carbon dioxide (low levels)	To maintain a moderate temperature on Earth.
More than 80 Dobson Units of Ozone in the stratosphere (high levels)	To protect animals and some plants from harmful radiation.
15 to 30% oxygen (medium levels)	For animals to breathe.
More than 5% nitrogen (high levels)	To provide proteins and other building blocks for life. On Earth, high levels of nitrogen also provide air pressure.

Note to Teacher: Students may have questions about Dobson Units. You may want to discuss with students that this is a different measurement used for ozone, because ozone is not distributed evenly throughout the atmosphere. It is concentrated into a layer high in the stratosphere. A Dobson Unit (DU) is a measurement of how thick the ozone layer would be if it were concentrated and brought down to the surface of the Earth and covered the entire planet. Earth's current level of 300 DU would measure 3 millimeters thick if it covered the planet's surface.

- Question: Of all of our human survival needs, for which ones does atmosphere have an important role?
- *Answer: Atmosphere plays a role in maintaining a moderate temperature, protecting us from harmful radiation, providing oxygen, water vapor and proteins in our food.*

- Put up the Human Survival Needs Transparency again and add this new information to it as follows: (Atmospheric factors are italicized to differentiate from Astronomy factors.)

Humans need:	**Reason:**	**What Factors Provide This:**
Food	Gives us energy so that we can move, grow and function. It also gives us nutrients to build and mend bones, teeth, nails, skin, hair, flesh and organs.	*Nitrogen is a nutrient*
Oxygen	Helps us to obtain energy from sugars.	*Oxygen helps us get energy from sugars*
Water	Allows nutrients to circulate through the body, allows the body to filter out waste and poisons, and helps to regulate body temperature.	(related to temperature) *Water vapor is a greenhouse gas in our atmosphere*
Moderate temperature (Average global temperature below 50° C)	Allows us to maintain an average body temperature of 98.6° F/37°C and to maintain water in a liquid state at all times.	Star type Orbital distance Planetary mass (Orbits of large planets/objects could disrupt) *Greenhouse gases reradiate heat*
Protection from poisonous gases and high levels of radiation	To prevent cancer, disease, and damage to the body.	*Ozone protects from UV* *Our atmosphere doesn't have high levels of poisonous gases*
Gravity	Allows our biological systems to develop and function normally.	Planetary mass *Nitrogen provides pressure*

Extend/Apply (approximately 15 minutes)

1. **Have students apply these atmospheric conditions to another planet in our Solar System.**
   - Have students choose another planet in our Solar System, and use the Planetary Atmosphere Comparison Chart to describe what atmospheric conditions would need to change in order for the selected planet to be habitable. They should record this information in the Creating Habitable Conditions for Other Planets section of their Astro Journals.

Evaluate (approximately 15 minutes)

2. **As a class, have students share their planet and discuss what atmospheric changes would be necessary to make it habitable to humans.**
   - Based on what students know so far, their assessments should include observations that all planets lack oxygen and ozone and some have too much carbon dioxide.

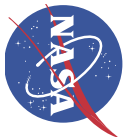
3. **Have students complete their Astro Journals.**

4. **Collect students' Astro Journals and evaluate them to ensure that they have each mastered the major concepts:**
   - We need the following levels of gases in our atmosphere:
     - 0.0001 to 20% water vapor
     - 0.001 to 0.03% carbon dioxide
     - more than 80 Dobson Units of Ozone in the stratosphere
     - 15 to 30% oxygen
     - More than 5% nitrogen

5. **Bridge to next lesson.**
   - Question: What do you think makes each gas different, giving it unique properties that contribute to human survival?
   - *Answer: (Allow students to discuss their ideas about this.)*

   - Say: In the next lesson, we will begin to look at the components of gases and determine each gas's unique properties, which determine its role in helping humans.

     Note to Teacher: After each lesson, consider posting the main concept of the lesson some place in your classroom. As you move through the unit, you and the students can refer to the "conceptual flow" and reflect on the progression of the learning. This may be logistically difficult, but it is a powerful tool for building understanding.



Astro Journal Atmosphere Lesson 1:
Atmospheric Science Training Module

Class/Period:

Name:

Date:

1. Scientific Question:

What atmospheric conditions are required for human survival?

2. Prediction: What atmospheric conditions do you think humans need to survive? Why?

3. Data: The following may be recorded and printed online. However, if you are unable to print from the computer, you may use the following chart to record your observations.

Cause	Effect on Earth
No water vapor	
Medium levels of water vapor	
High levels of water vapor	
No carbon dioxide	
Low levels of carbon dioxide	
Medium levels of carbon dioxide	
High levels of carbon dioxide	
No ozone	
High levels of ozone	
No oxygen	
Medium levels of oxygen	
High levels of oxygen	
No nitrogen	
High levels of nitrogen	

Astro Journal Atmosphere Lesson 1:
Atmospheric Science Training Module

Name:

Class/Period:

Date:

4. Results: What atmospheric conditions are required for human survival? Why? (Create a revised list below based on what you learned from the Atmospheric Training Module.)

5. Conclusions: Compare and contrast your prediction and results. How did conducting research change your original ideas?

6. Creating Habitable Conditions for Other Planets. Choose another planet in our Solar System. Write a paragraph explaining what atmospheric conditions would need to change in order for this planet to be habitable and why.

Atmospheric Science Training Walkthrough

The following is an explanation of each section of Atmospheric Science Training. It offers suggestions for how you might take a whole class through the module, if you only have one computer with the ability to project the screen image for classroom viewing.

Introduction

1. Go through the introduction with students. This introduces types of atmospheric careers and explains the activity students will be going through to make changes to different gases in the Earth's atmosphere, to observe the effects, and to record these effects.

2. Enter a name for the class, and click "Enter."

3. When you first enter the main activity, there is a movie that shows the Earth, the layers of the atmosphere, and the gases that compose the atmosphere and where they are located. This movie only plays once and cannot be repeated. All buttons are inactive during this short movie.

Activity

1. Astro Ferret directs you through the steps the first time. After that you are on your own, but can click Astro for a reminder.

2. Click "Water Vapor."

3. Click "none."

4. Ask students what they predict will happen to Earth.

5. Click "Play" to see the effect on Earth.

6. Ask students to describe what happened to Earth and why. You can click the "Replay" button to see the animation as many times as is you want. Also, you may want to click Astro Facts to read background information that may help to understand what is happening in the animations.

   Note to Teacher: "Replay" can be clicked multiple times to see the effect again.

7. Have students record their observations in the Data section of their Astro Journal.

8. Call on individuals to share what they wrote and have them type their observations in the Astro Journal on the computer. Ask students if they think "no water vapor" allows Earth to be habitable and why or why not.

9. Record a good example of the kinds of observations you expect from students such as: "First the animals died. Then the plants died. It became cold."

   Note to Teacher: The sequence of events in this module is important. You may want to model this for students.

10. Explain that a good scientific observation is detailed and describes what is observed.

11. Tell students that since they will be able to use their notes when they take the Astro Challenge, they should take thorough notes.

12. Click "Enter" to see other scientists' observations. Stress to students that they don't need to type the exact same thing, but should have the same general idea.

    Note to Teacher: Students can change their answer after they click "Enter." Both answers will be printed in their Astro Journal so that you can see if they are making good, initial observations.

13. Point out to students that when they have completed an observation, that button turns purple. They must complete all observations in all five major sections before they can advance to the Astro Challenge section.

14. Click "medium."

15. Click "Play."

16. Ask students to give a detailed observation such as: "The Earth remains habitable."

Completion of Activity

1. Continue through each level of "Water Vapor," "Carbon Dioxide," "Ozone," "Oxygen," and "Nitrogen."

2. Have the class record their observations in their Astro Journals and then have individuals take turns typing in their observations in the computer.

3. Have students record in their Astro Journals the levels of each gas that resulted in a habitable Earth.

4. After all observations have been completed, click "Astro Challenge" on Astro Ferret and take the Astro Challenge as a class.

5. Encourage students to go back to the relevant sections and look at their notes in their Astro Journal to help answer the questions.

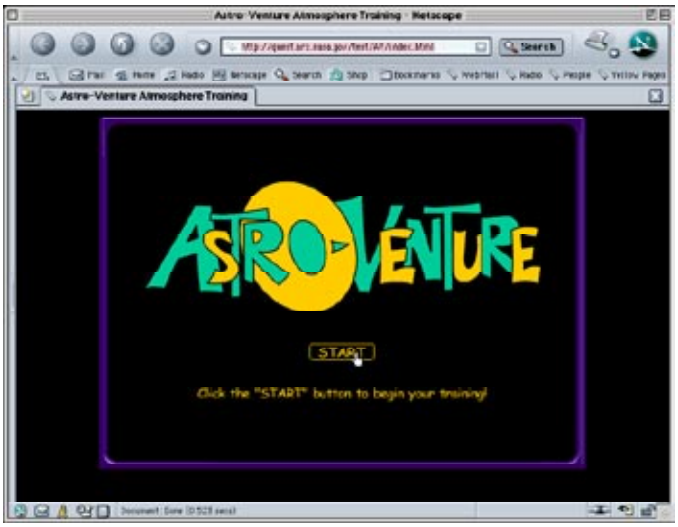
6. Have students vote on the answers.

Conclusion

1. Have students vote on the results that they found. Discuss how their results compare to their predictions.

2. Print the class certificate and the class Astro Journal, if you wish.

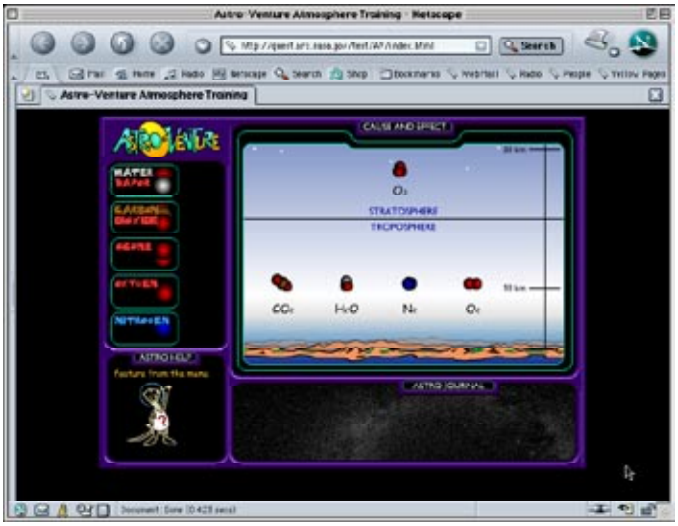
Atmospheric Science Training Module Screen Shots



1. Press start to begin Training Module.

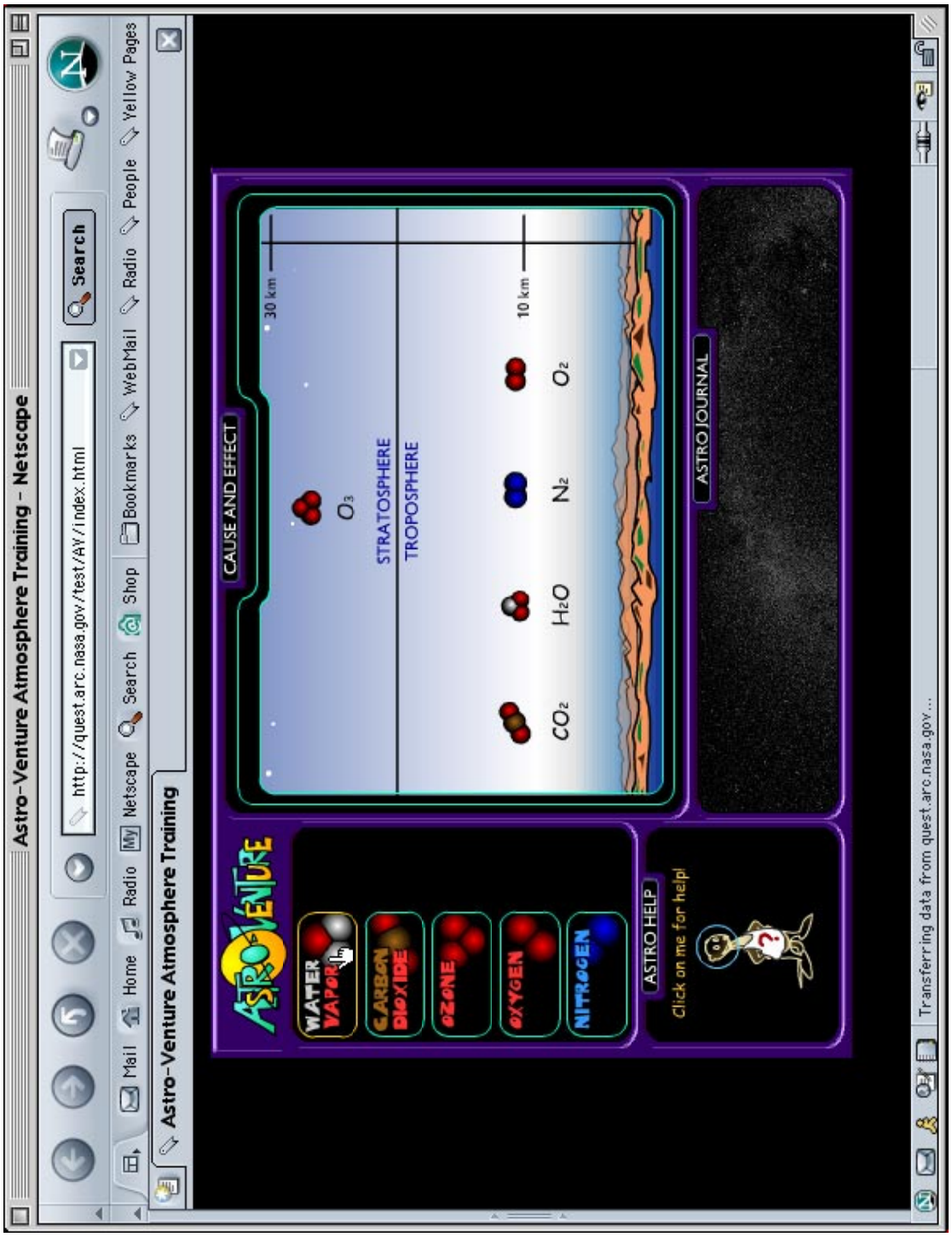
2. Astro Ferret introduction featuring NASA careers

3. Enter your name or your team's name.



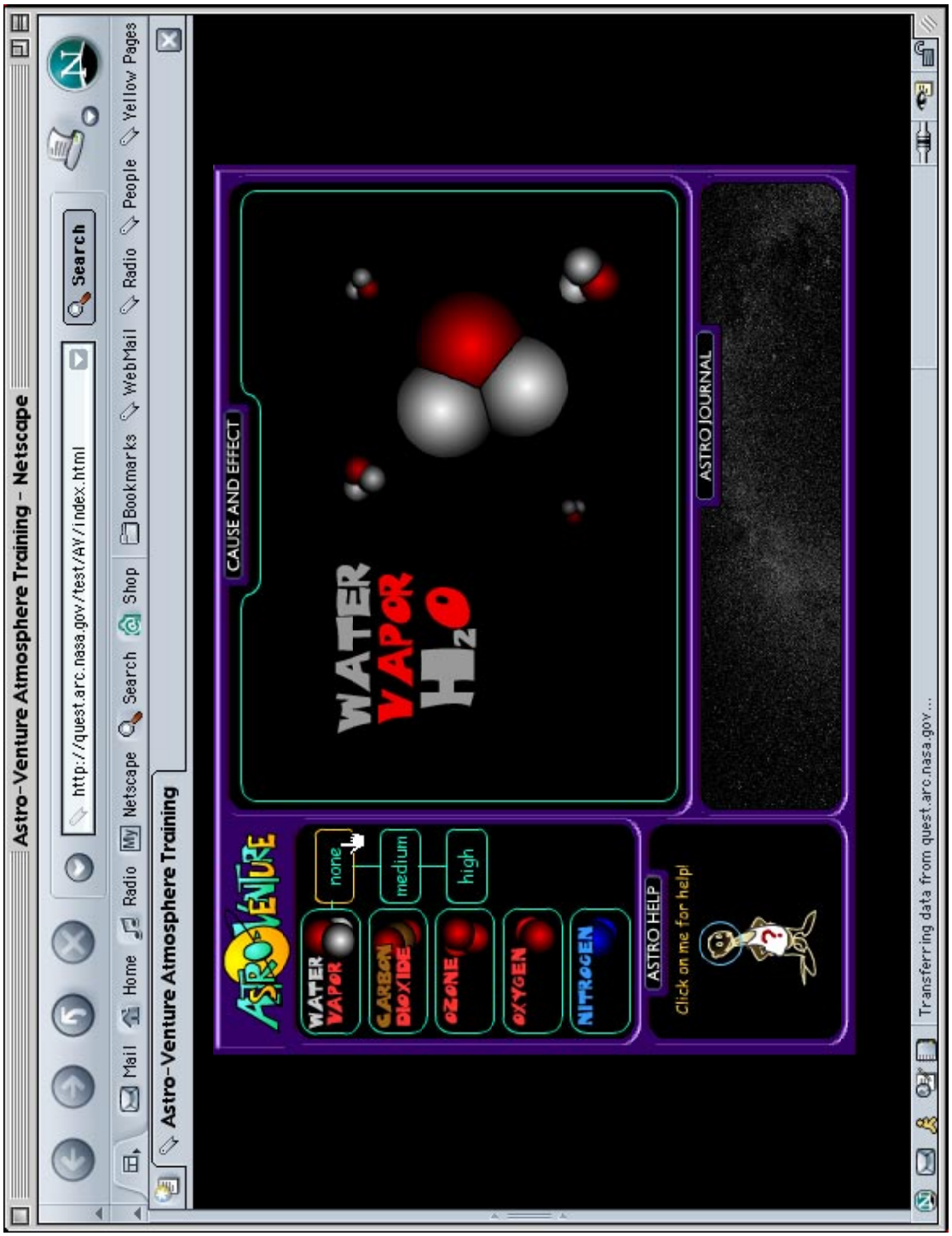
4. Astro Ferret introduces the Atmospheric Science module.

Atmospheric Science Training Module Screen Shots



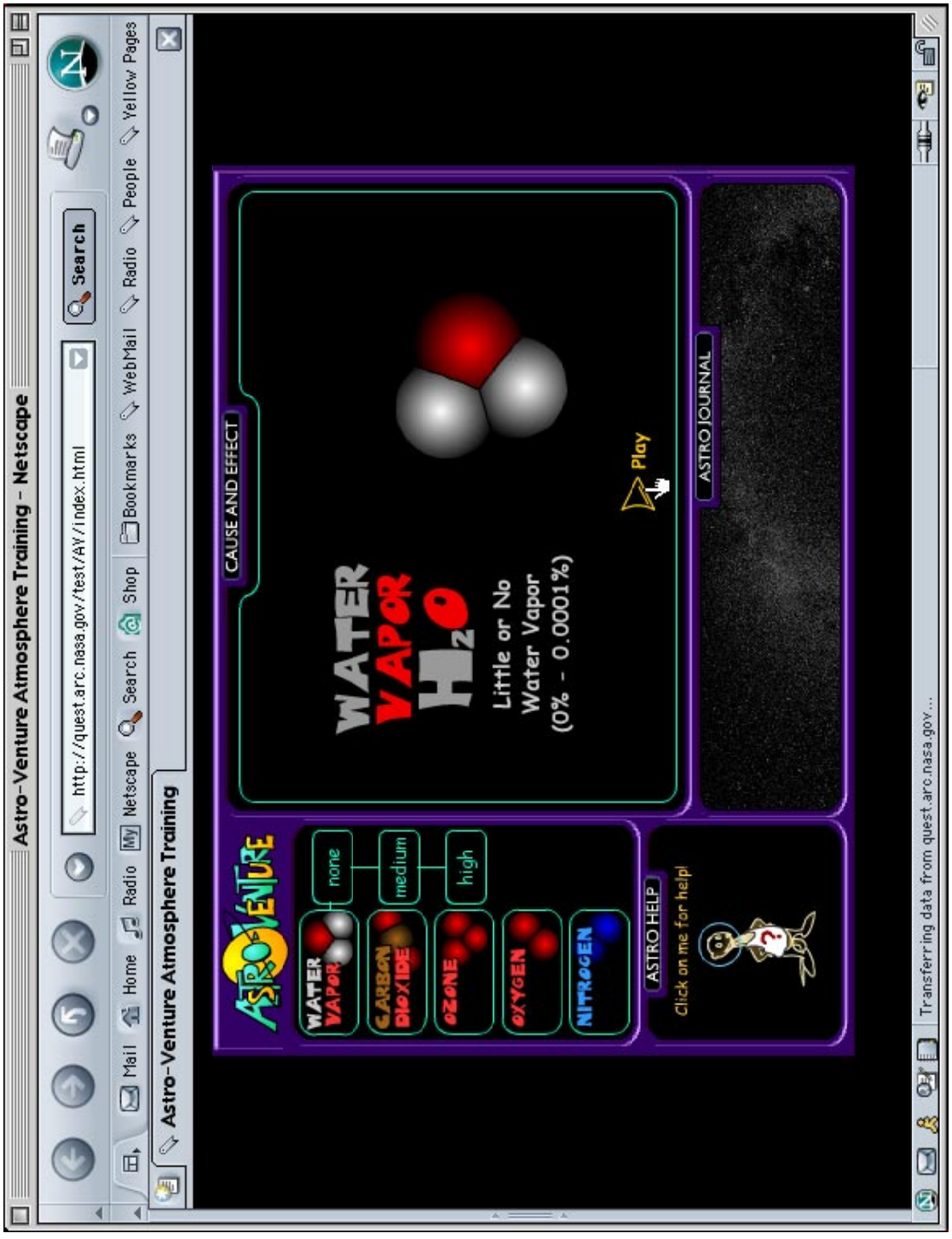
4A. Select a feature such as "Water Vapor"

Atmospheric Science Training Module Screen Shots



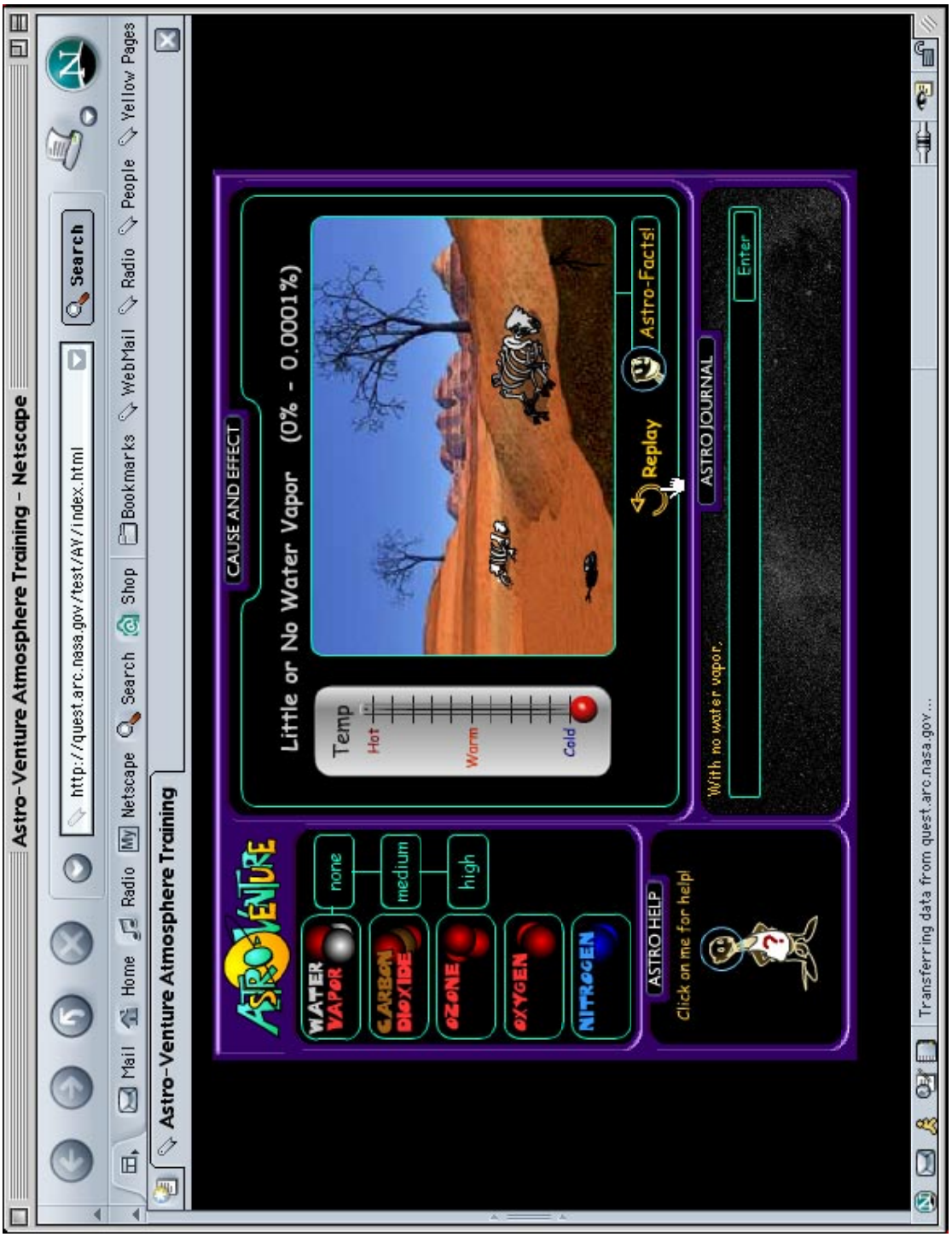
4B. Select a sub-menu such as "None." to cause a change in our Earth's atmosphere.

Atmospheric Science Training Module Screen Shots



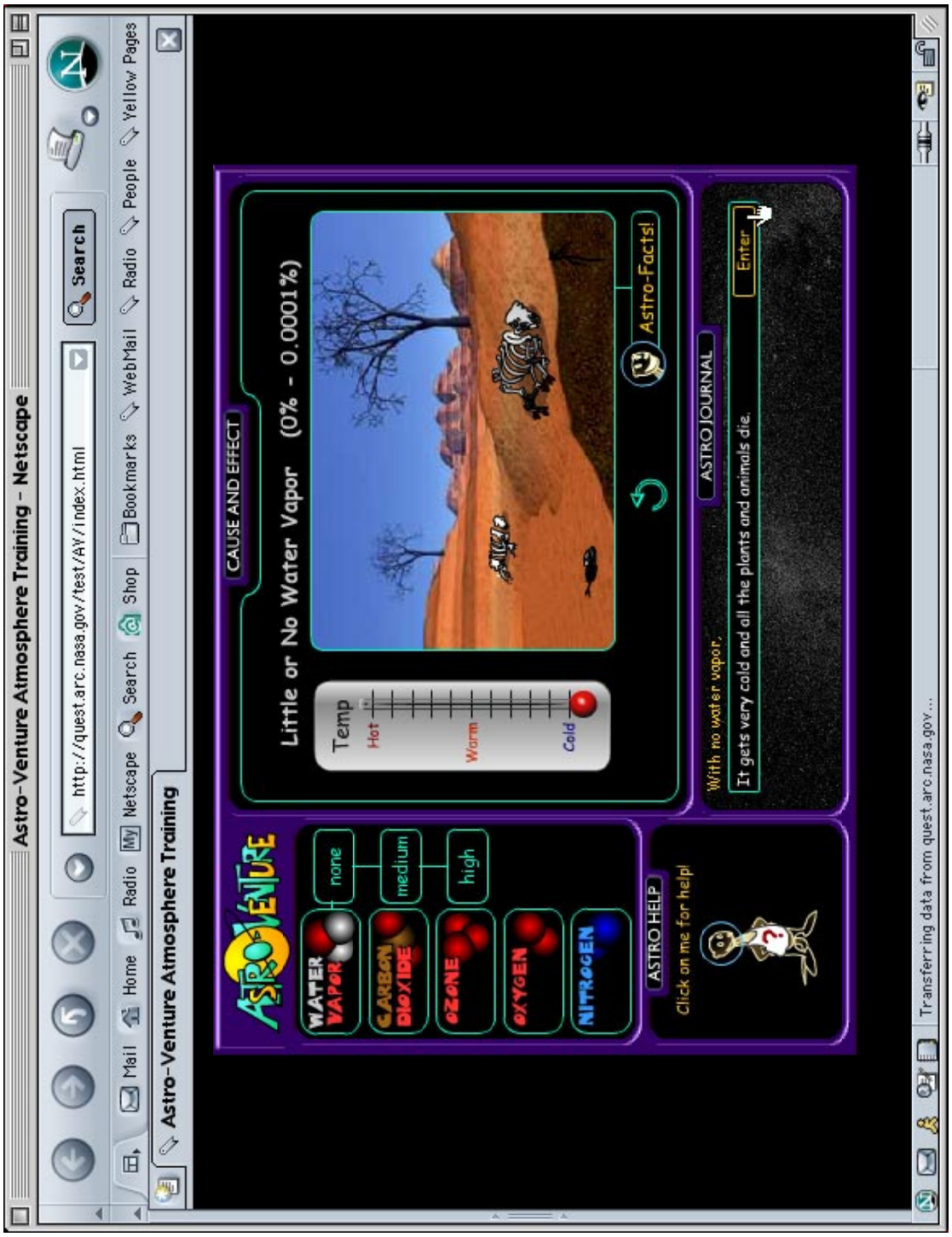
4C. Click "Play" to see the effect on Earth.

Atmospheric Science Training Module Screen Shots



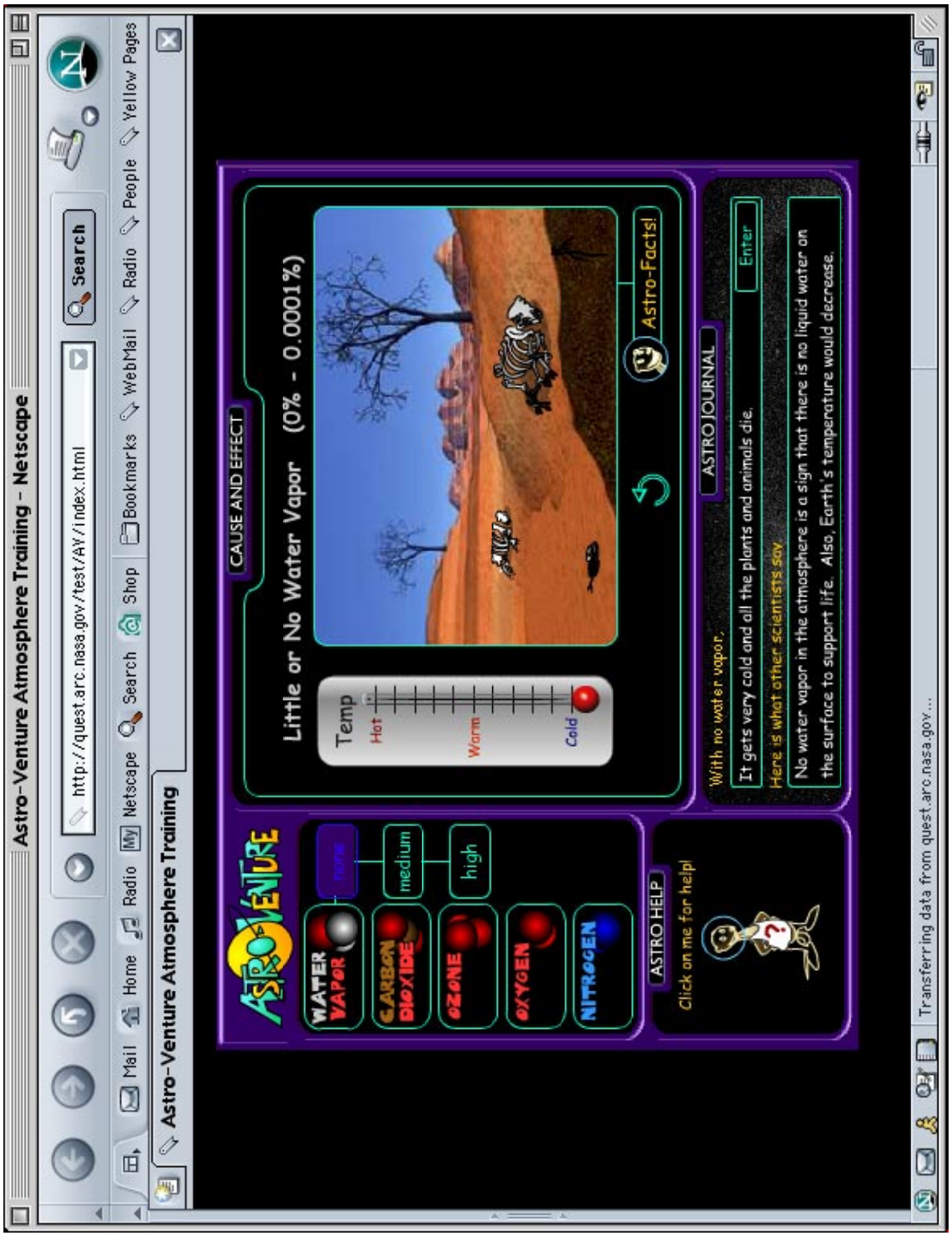
The "Replay" button can be clicked repeatedly to view effect on Earth again.

Atmospheric Science Training Module Screen Shots



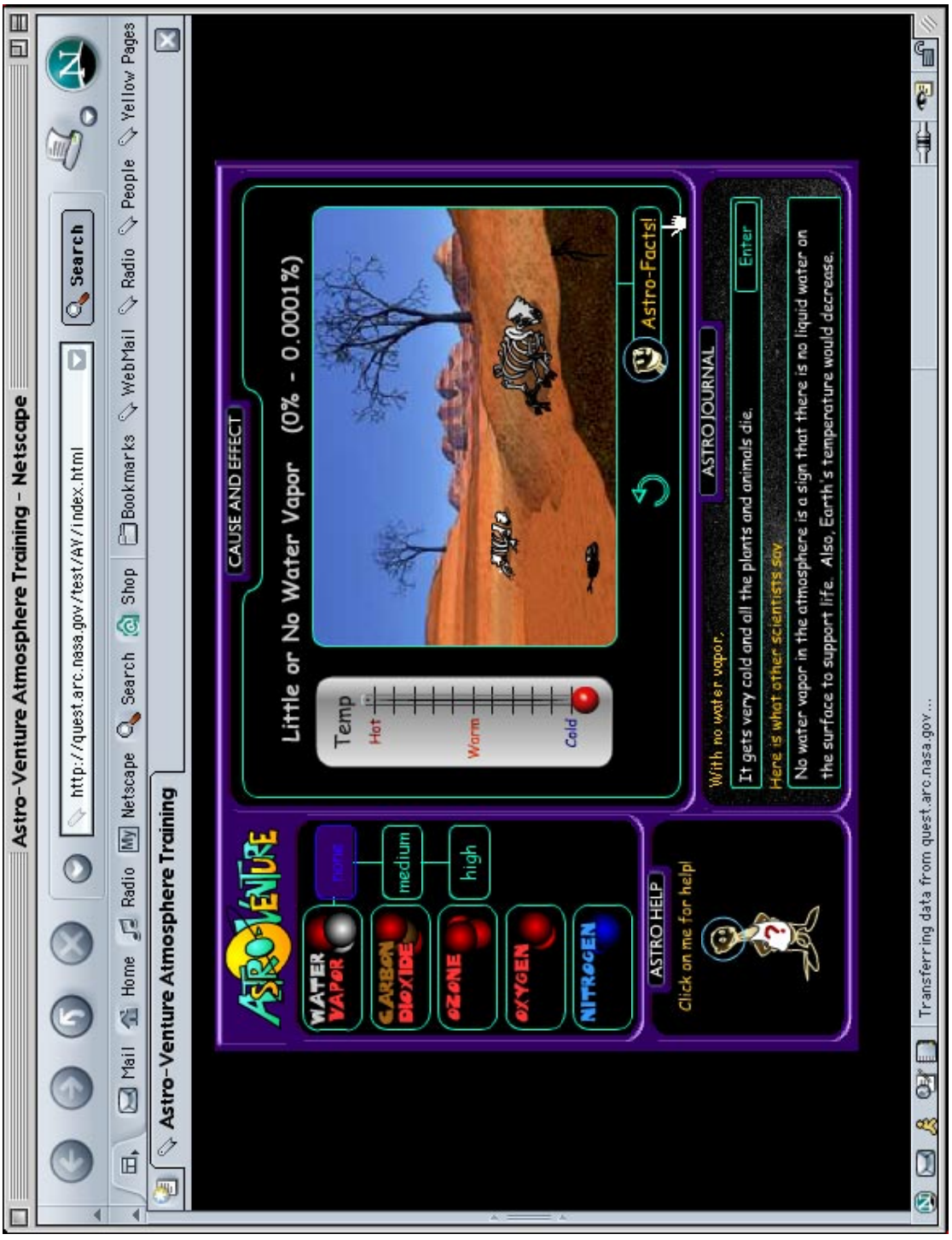
4D. Record what you observe in your Astro Journal.

Atmospheric Science Training Module Screen Shots



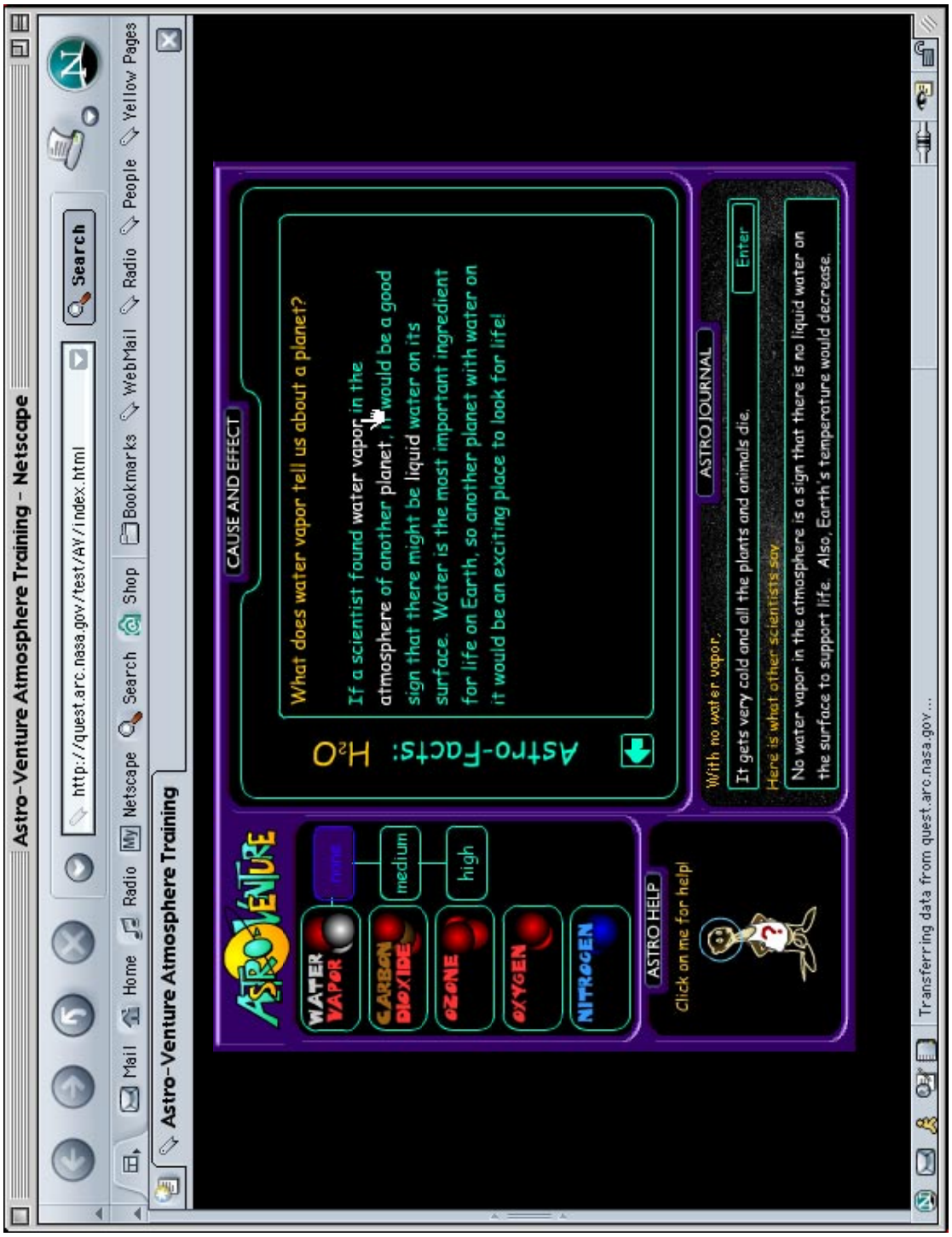
4E. Be sure to read the Scientist's feedback.

Atmospheric Science Training Module Screen Shots



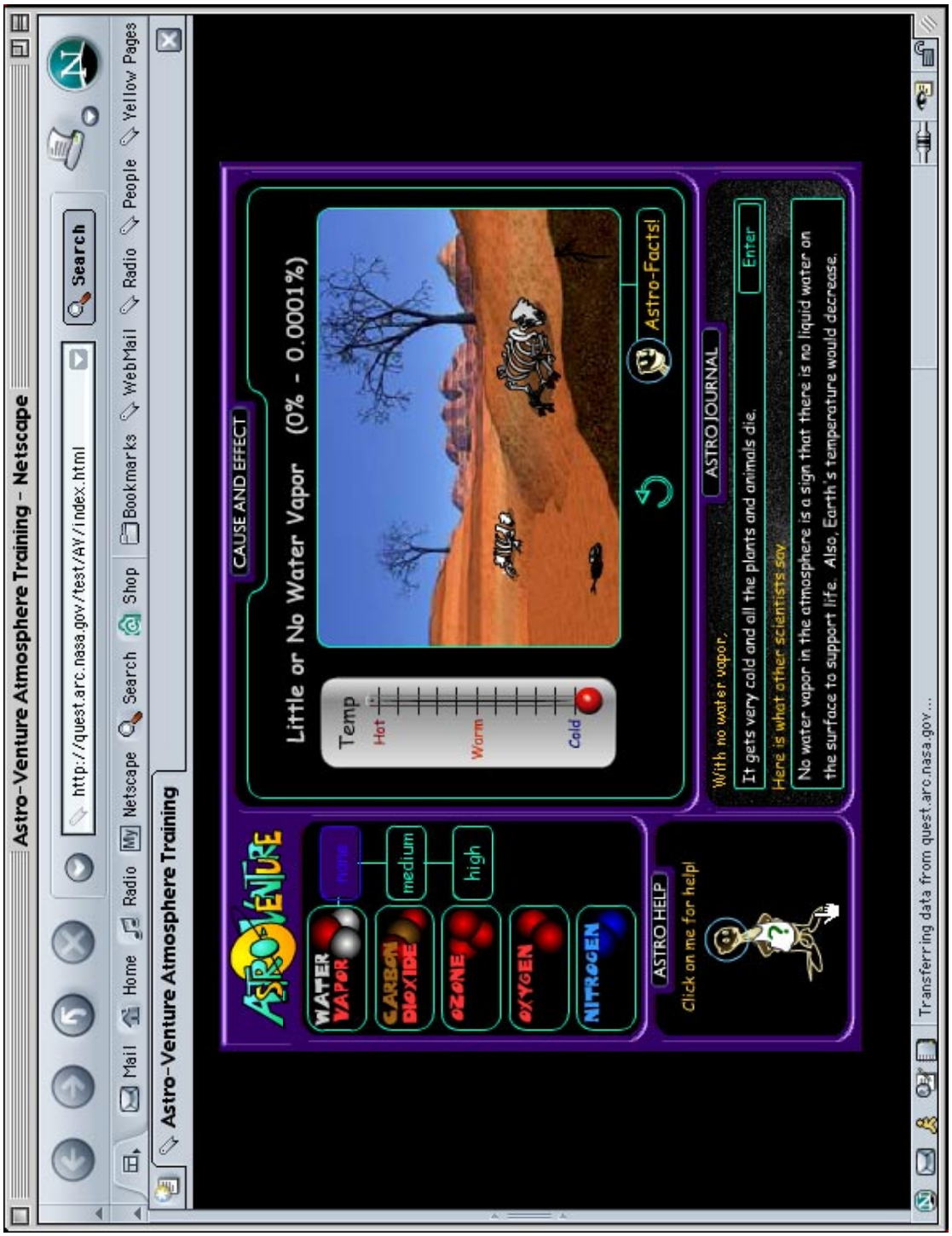
4F. Click on the Astro Facts button for background information and a glossary.

Atmospheric Science Training Module Screen Shots



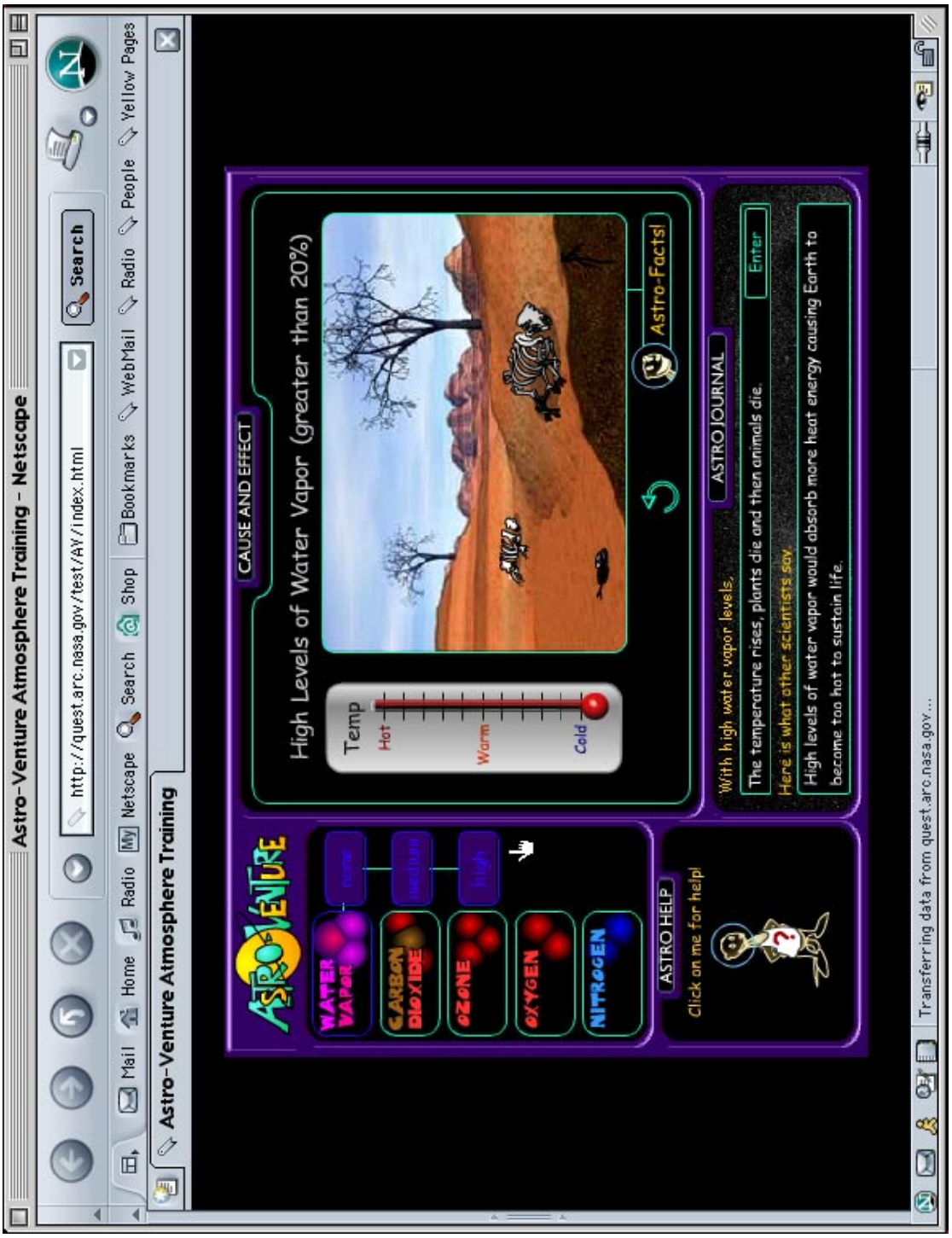
4G. Click on highlighted words in the Astro Facts for glossary definitions.

Atmospheric Science Training Module Screen Shots



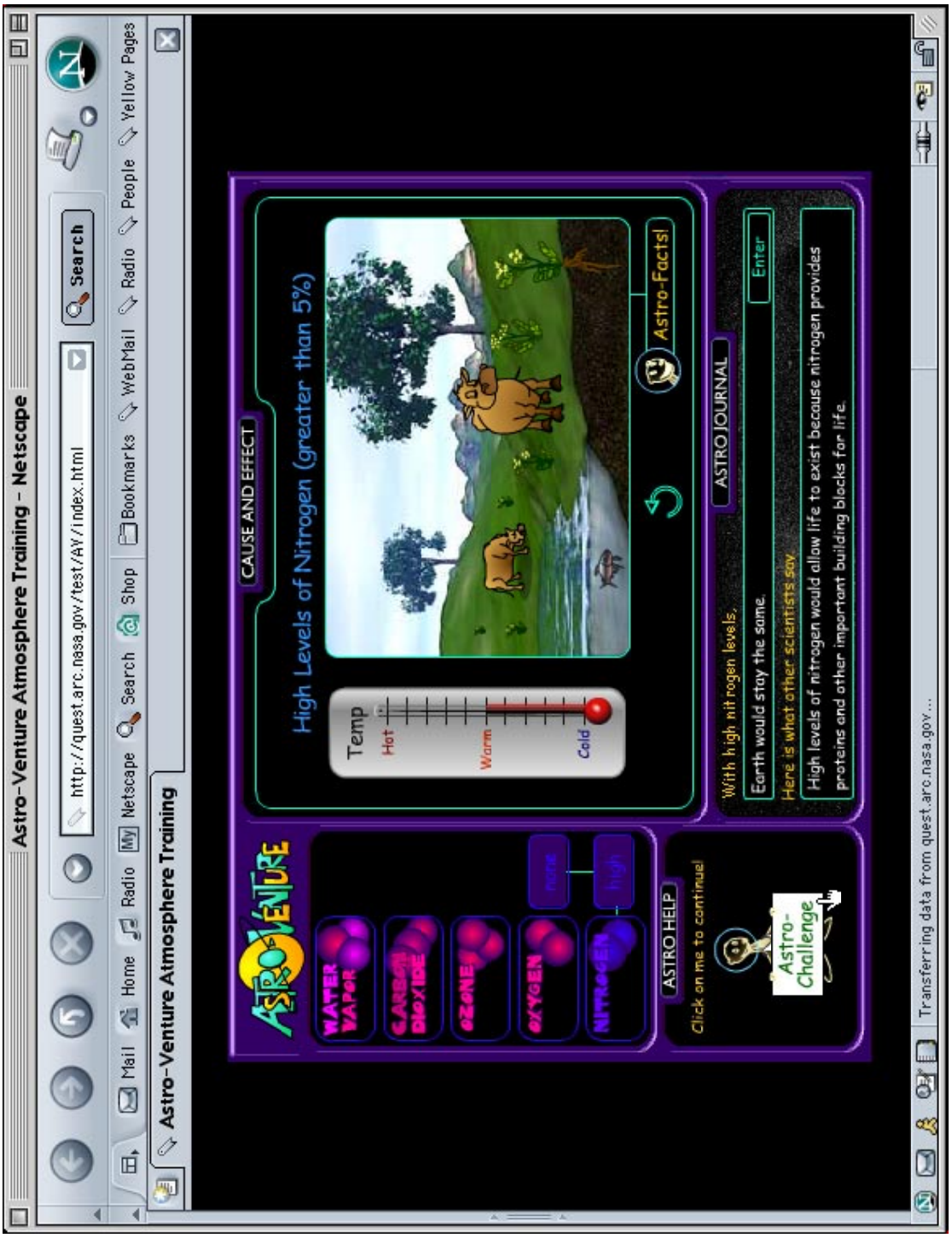
4H. Click on Astro Ferret if you need help navigating through the module.

Atmospheric Science Training Module Screen Shots



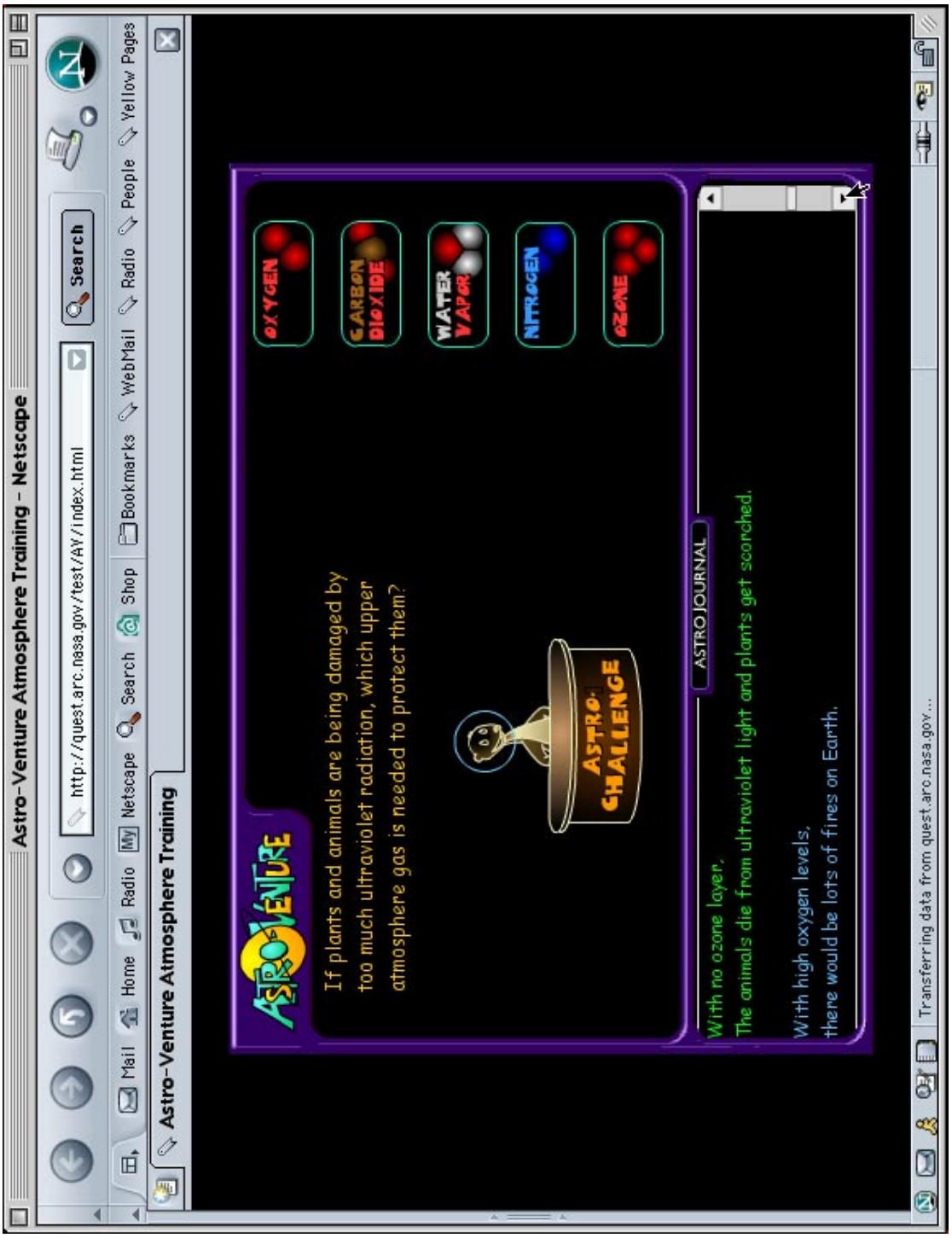
4I. Continue using steps 4A-4H for all other features and sub-menus and record your observations. (Buttons will turn purple once you have completed that section.)

Atmospheric Science Training Module Screen Shots



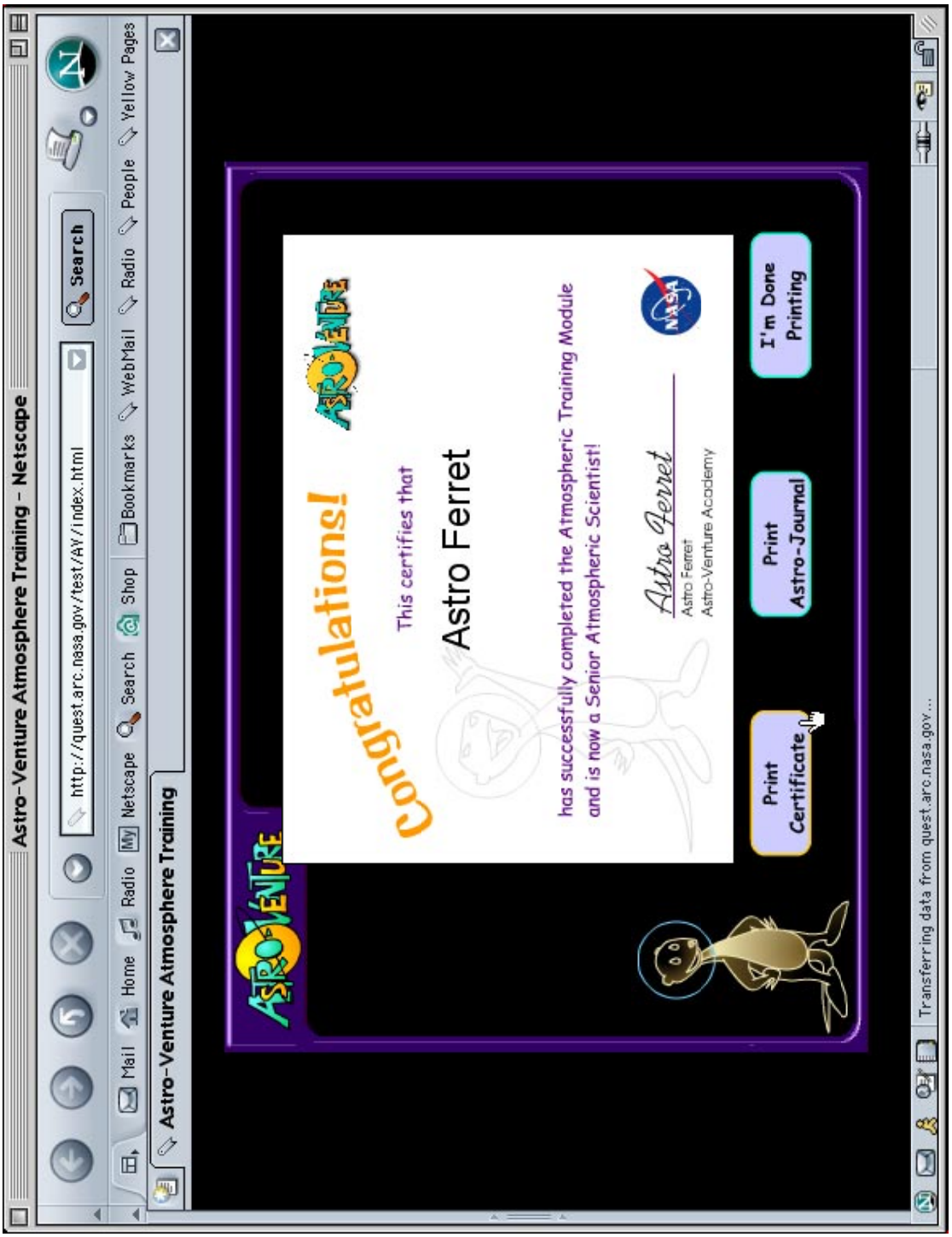
5. When you have completed all of your observations, Astro Ferret will appear with the Astro Challenge button. Click the button to begin your Astro Challenge.

Atmospheric Science Training Module Screen Shots



6. Astro Challenge. Be sure to use your notes in your Astro Journal to help you.

Atmospheric Science Training Module Screen Shots



7. You can print your certificate, and Astro Journal.

Meteorologist

Related Job Titles:

Weather Officer, Weather Forecaster, Meteorology Researcher, Meteorological Modeling Specialist

Job Description:

The Meteorologist collects weather data, surveys weather indicators and makes predictions regarding developing weather patterns. This individual advises air traffic control and other agencies about weather hazards such as thunderstorms, developing storm cells and fronts, turbulence, tornadoes, icing, flooding, flash flooding and other such weather-related phenomena. They issue to various governmental agencies and the public weather advisories for vehicles, aircraft and watercraft. They use sophisticated computer software programs that assist them in modeling the potential flow and intensity of storm cells and fronts. They are also available to participate in weather-related research projects that seek to provide more accurate forecasting methods over a longer time period.

Interests / Abilities:

- Do you read and understand charts with special symbols easily?
- Can you perform calculations quickly with great accuracy?
- Do enjoy getting out a road map and figuring out what route to drive when preparing for vacation? Can you see more than one route to a destination?
- Are you curious about your surroundings and what processes shape them?
- Are you patient when it comes to completing forms requiring detailed information?

Suggested School Subjects / Courses:

- Math (algebra, trigonometry)
- Physics
- Meteorology
- Statistics
- Computer modeling
- Geography

Education / Training Needed:

The minimum education required for this position is a bachelor's degree in meteorology or Atmospheric Sciences from an accredited college or university. Experience in computer modeling techniques is extremely helpful for this job. To do research, at minimum a master's degree is required and a Ph.D. is highly desired for this position.

Areas of expertise:

- *Aeronautical*: study weather phenomena and its effects on flight (lightning, icing, etc.)
- *Synoptic*: analyze data from satellites, radar, and surface-observing instruments
- *Weather forecasters*: prepare forecasts for public and specialized reports for aviation, marine and agriculture
- *Research*: study atmospheric physics, refine theories and improve mathematical/computer models of atmospheric processes and events
- *Climatologists*: collect, organize, archive, interpret and publish climatological data.

Additional Resources:

- National Oceanic and Atmospheric Administration
  http://www.noaa.gov
- National Severe Storms Laboratory
  http://www.nssl.noaa.gov
- National Weather Service
  http://www.nws.noaa.gov
- Schools with programs in meteorology
  http://www.nssl.noaa.gov/edu/schools.html
- American Meteorological Society
  45 Beacon St., Boston, MA 02108
  http://www.ametsoc.org/AMS

What can I do right now?

- Set up your own weather station and provide your local radio station with a daily report.
- Get some work experience at the local airport, television or radio station as a weather data compiler or weather statistics researcher.
- Learn to read and interpret the various types of weather maps, charts and data available through the Internet.
- Learn how to use database software.

Atmospheric Chemist

Related Job Titles:

Atmospheric Scientist, Environmental Scientist, Air Quality Analyst, Meteorologist, Atmospheric Physicist

Job Description:

Atmospheric chemistry is a multi-disciplinary field that is a sub-set in the broader field of atmospheric science. Atmospheric Scientists are interested in the chemical composition of the atmosphere and how the gases of the atmosphere interact with each other. Atmospheric Chemists make oberservations and collect data to understand how the atmosphere reacts and changes with sunlight and with many parts of the Earth's surface including soils, vegetation, oceans, ice and snow. Some atmospheric chemists analyze the composition of our current atmoshere to compare with past data to understand the local, regional, and global effects of our industrial practices. Atmospheric Chemists can also help gain an understanding of a distant planet's composition because they can analyze the chemistry of a planet's atmosphere from a distance.

Interests / Abilities:

- Are you interested in the world around you and the processes that effect our planet?
- Can you do math quickly and correctly?
- Are you patient when completing forms that require detailed information?
- Do you like to solve logic puzzles?
- Are you a good problem solver?

Suggested School Subjects / Courses:

- Chemistry
- Math (algebra, trigonometry)
- Physics
- Meteorology
- Statistics
- Computer modeling
- Environmental studies
- Electronics

Education / Training Needed:

The minimum education required for this position is a bachelor's degree in atmospheric sciences or chemistry from an accredited college or university. Experience in hands-on laboratory techniques is extremely helpful for this job. To do research, at minimum a master's degree is required and a Ph.D. is highly desired for this position.

Areas of expertise:

- *Synoptic*: analyze data from satellites, radar, and surface-observing instruments
- *Research*: study atmospheric chemistry, refine theories and improve mathematical/computer models of atmospheric composition and its impacts on the planet
- *Environmental*: monitor pollution from traffic and industry and its effects on the planet

Additional Resources:

- National Center for Atmospheric Research-Atmospheric Chemistry Division
  http://www.acd.ucar.edu
- Atmospheric Chemistry and Physics Interactive Science Journal
  http://www.copernicus.org/EGU/acp/
- National Oceanic and Atmospheric Administration
  http://www.noaa.gov
- National Weather Service
  http://www.nws.noaa.gov
- American Meteorological Society
  45 Beacon St., Boston, MA 02108
  http://www.ametsoc.org/AMS

What can I do right now?

- Buy a chemistry set and learn how different substances interact with each other.
- Set up your own weather station and provide your local radio station with a daily report.
- Read newspapers and magazines to understand how governments and industries make policies related to atmospheric composition.
- Take samples of rain or soil in your neighborhood and analyze them using water and soil test kits from your local hardware store.

Planetary Atmospheric Scientist

Anthony Colaprete

Research Scientist

Contractor, National Research Council
NASA Ames Research Center

I build computer models of planetary atmospheres and design instruments that make measurements. Current efforts are toward the NASA Ames Mars general circulation model (GCM), a 3D dynamical model that simulates Martian weather and climate. Specifically I am working on including clouds and dust into the CGM. I also am a Co-Investigator on a proposed Mars mission called Pascal. Pascal consists of 18 individual probes that land all over the Martian surface. As a Co-Investigator I am in change of developing a digital camera that will take pictures of the Martian surface during probe descent.

Areas of expertise:

- Planetary Atmospheres

How I first became interested in this profession:

I think I've been interested in nature and ecology from the time I was born. As a kid, I was happier running around the woods than sitting at home in front of a TV. My father introduced me to space science and engineering early with "at-home" experiments we would perform together. By the time I was in high school I knew I wanted to be involved in the space sciences. Later in college I realized that I could bring my love for nature and space together by studying the nature of other worlds.

What helped prepare me for this job:

I think all that time I spent running around in the woods helped me the most. While in the woods I would sit and watch how things worked together, how the forest was composed of lots of parts that made a system. Watching the natural system of the forest taught me to observe other systems and recognize trends, relationships and causalities. That is my strongest attribute and helps me every day as I look at data from Mars or Earth. Of course I studied a lot (something I was never very good at) and that helped me build the tools that I use every day at work.

My role models or inspirations:

There were many. First was my father. When I was about 7, he and I cut a battery in half to figure out how it worked (my father is an engineer and knew how to do this without anyone getting hurt!). My wife is a huge source of motivation for me and makes me realize just how wonderful and amazing the entire universe is. Luckily my thesis advisor had enough faith in my abilities to let me make some really good mistakes! He always helped guide me but still let me go off exploring my own crazy ideas.

My education and training:

- 1992 B.A., Physics, University of Colorado
- 1998 M.S., 2000 Ph.D., Astrophysical, Planetary and Atmospheric Science, University of Colorado

My career path:

- 10 years at Colorado Space Grant College--design, fabrication, calibration and flight analysis of instrumentation on shuttle and satellite missions.
- 8 years at the Laboratory for Atmospheric and Space Physics--aerosol modeling for Mars Pathfinder and Mars Global Surveyor.

What I like about my job:

Being a planetary scientist is like being a storyteller. You get to come up with new stories or ideas about how a planet works. My job combines modeling with measurements which lets me work with instruments and missions to other worlds.

What I don't like about my job:

Sometimes there is a lot of paper work that needs to be done that has nothing to do with science. That's a drag.

My advice to anyone interested in this occupation:

Develop the tools needed to be a scientist early on! If you know your math and physics, it frees up your time to think about the real problems. Learn to observe and ask questions. All science starts with an observation, an idea or a question.

Planetary Atmosphere Comparison Chart

Planet	Amount of Atmosphere	Atmospheric Composition
Mercury	Trace atmosphere = .000000000000010 bars*	42% oxygen (O_2) 29% sodium (Na), 22% hydrogen (H_2) 6% helium (He) 0.5% potassium (K), possible trace amounts of: argon (Ar), carbon dioxide (CO_2), water (H_2O), nitrogen (N_2), xenon (Xe), krypton (Kr), neon (Ne)
Venus	Atmosphere = 92 bars	96.5% carbon dioxide (CO_2) 3.5% nitrogen (N_2) water (H_2O) – 0. 0020% trace amounts of: sulfur dioxide (SO_2), argon (Ar), carbon monoxide (CO), helium (He) and neon (Ne)
Earth	1 bar (at sea level)	78% nitrogen (N_2) 21% oxygen (O_2) 0.035% carbon dioxide (CO_2) 1 to 4% water vapor (H_2O) 300 Dobson Units ozone (O_3) 0.002% methane (CH_4) 0.9% argon (Ar) trace amounts of: helium (He), krypton (Kr) and hydrogen (H_2)
Moon	0 bars	None
Mars	Atmosphere = 0.0061 bars	95.32% carbon dioxide (CO_2) 2.7% nitrogen (N_2) 1.6% argon (Ar) 0.13% oxygen (O_2) 0.08% carbon monoxide (CO) water (H_2O) – 0.0210%; trace amounts of: nitrogen oxide (NO), neon (Ne), hydrogen-deuterium-oxygen (HDO), krypton (Kr) and xenon (Xe)
Jupiter	Atmosphere > 1000 bars	89.8% hydrogen (H_2) 10.2% helium (He) 0.3% methane (CH_4) ~0.0004% water (H_2O) (varies with pressure) trace amounts of: ammonia (NH_3), hydrogen deuteride (HD) and ethane (C_2H_6)
Saturn	Atmosphere >1000 bars	96.3% hydrogen (H_2) 3.25% helium (He) 0.45% methane (CH_4) trace amounts of: ammonia (NH_3), hydrogen deuteride (HD) and ethane (C_2H_6)
Uranus	Atmosphere > 1000 bars	82.5% hydrogen (H_2) 15.2% helium (He) ~2.3% methane (CH_4) trace amounts of: hydrogen deuteride (HD)
Neptune	Atmosphere > 1000 bars	80.0% hydrogen (H_2) 19.0% helium (He) 1.5% methane (CH_4) trace amounts of: hydrogen deuteride (HD) and ethane (C_2H_6)
Pluto	Atmosphere ~0.000003 bars	Methane (CH_4), nitrogen (N_2)

* A bar is the average atmospheric pressure at sea level on Earth.

Human Survival Transparency

Humans need:	Reason:	What Factors Provide This:
Food	Gives us energy so that we can move, grow, and function. It also gives us nutrients to build and mend bones, teeth, nails, skin, hair, flesh, and organs.	
Oxygen	Helps us to obtain energy from sugars.	
Water	Allows nutrients to circulate through the body, allows the body to filter out waste and poisons and helps to regulate body temperature.	
Moderate temperature (Average global temperature below 50º C)	Allows us to maintain an average body temperature of 98.6° F/37°C and to maintain water in a liquid state at all times.	
Protection from poisonous gases and high levels of radiation	To prevent cancer, disease and damage to the body.	
Gravity	Allows our biological systems to develop and function normally.	

Atmospheric Conditions

Reason					
Observed Atmospheric Condition					
Predicted Atmospheric Condition					